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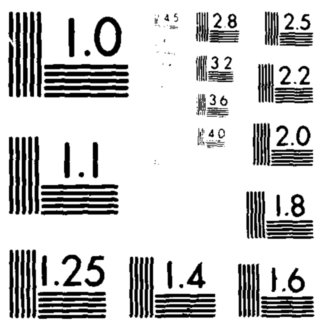

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THE DEPARTMENT OF DEFENSE STATEMENT ON THE SCIENCE AND TECHNOLOGY PROGRAM

by

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DR. ARDEN L. BEMENT, JR.
DEPUTY UNDER SECRETARY OF DEFENSE FOR
RESEARCH AND ADVANCED TECHNOLOGY

(12) 61

BEFORE THE
RESEARCH AND DEVELOPMENT SUBCOMMITTEE
OF THE
COMMITTEE ON ARMED SERVICES
OF THE
UNITED STATES SENATE
96th CONGRESS, SECOND SESSION

(11)

5 MARCH 1980

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The FY 1981 Department of Defense

Program for Science and Technology

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I

Mr. Chairman and Members of the Committee:

I. OVERVIEW OF THE SCIENCE AND TECHNOLOGY PROGRAM

I am grateful for the opportunity to testify in support of the Department of Defense FY 1981 Science and Technology (S&T) Program. It gives me an opportunity to highlight some of the many significant contributions it is making in multiplying the effectiveness of our forces, in insuring that we retain our technological lead, and in precluding technological surprise by an adversary who continues to place high value on and investment in military R&D capabilities. Although this is the first time I have had the pleasure of addressing this Committee, I am aware of the steadfast support you have given the S&T Program in recent years and the appreciation you have for its contribution to our national security.

My predecessors have expressed concern over the technological surprise that might result from the twofold investment the Soviet Union is making in their military research and development program compared with that of the United States. Such potential surprise is intensified by the secrecy with which the Soviets cloak their activities. Furthermore, it is becoming increasingly evident that while we still maintain a lead in most important fields of defense science and technology, the Soviet Union is steadily eroding this lead and is making surprising progress in applying sophisticated technology to improve the effectiveness of their new weapons. These qualitative advances, when coupled with their overwhelming numerical superiority, underscore the need for our heavy reliance on technology as a counterbalance. It is essential that we

aggressively maintain our technological leadership. In addition, however, we must apply creative management methods to amplify its rate of implementation to achieve the unambiguous strength necessary to deter armed conflict or to successfully conclude it should it occur.

The sustained growth in the S&T Program over the past three years has made possible a number of beneficial initiatives which were not possible during the "undernourished" years of the early 1970's. We are making substantial progress in closing the interfaces between the S&T Program and Advanced Development Programs to improve the flow of technology toward application. We are strengthening our relationship with universities in order to use the research and development resources of the academic community more effectively. We are able to increase the pace of progress in the research and development cycle through focused investments, critical mass funding, multidisciplinary attack on complex problems, and coupled programs involving university, industrial, and DoD laboratory research teams working in concert to exploit a high-payoff opportunity or meet a military requirement. We are able to tackle critical shortages in the number of defense scientists and technologists by encouraging the participation of underutilized and underrepresented segments of our society. Finally, we are able to replace obsolete research equipment and provide the advanced research tools necessary to maintain a modern and responsive defense capability. The flexibility to affect this progress has only recently been achieved and can easily be lost if real growth is not sustained. Continuity in policy and investment is the most important

ingredient for building a defense research base which will provide for our future national security.

In addition to multiplying our force effectiveness through improved performance, new technology is required to address defense costs, acquisition barriers, and readiness. Requirements that must be addressed by technical solutions include: improved reliability (which is "designed-in" and "manufactured-in" not just "tested-in"); life extension and durability of costly military hardware; conservation, substitution, and recycling technologies for critical materials; increased productivity and reduced manufacturing costs in our defense industrial base; the capability to substitute synthetic fuels for petroleum-based fuels; and improved human engineering to better match operational demands of new equipment to training and readiness levels. Advanced Technology Developments and the Manufacturing Technology Program provide great potential for meeting these requirements and accordingly deserve stronger emphasis in the future than is represented in our FY 1981 budget request. I intend to continue to give strong emphasis to these important elements of the S&T Program as well as to increased support for the engineering sciences at universities.

Finally, there are advantages inherent in a free society that enhance our ability to maintain technological leadership second to none. First and foremost, scientists are more creative when they work on their toes than on their knees. Furthermore, we have a strong and vigorous Independent Research and Development (IR&D) Program in our civil sector which has no counterpart in the Soviet Bloc. Also, our Allies with whom we collaborate

freely are high technology countries with extensive military and civil research and development programs. I will vigorously pursue new initiatives that will amplify the collective contributions of these resource bases to our overall technological capability.

Our request for the DoD S&T Program in FY 1981 is $3.5 billion. This is approximately two percent of the total DoD budget. The details are outlined in Table V-1.

Table V-1
Science and Technology Program
(Dollars in Millions)

	FY 1980	FY 1981
Research		
Services	467	559
Defense Agencies	91	93
Total Research	558	652
Exploratory Development		
Services	1,162	1,405
Defense Agencies	541	667
Total Exploratory Development	1,703	2,072
Advanced Technology Developments	638	612
TOTAL SCIENCE AND TECHNOLOGY PROGRAM	2,899	3,336
Manufacturing Technology (Non-RDT&E)	158	150

NOTE: To make FY 1981 Research and Exploratory Development growth comparable with FY 1980, it is necessary to consider $72M in high energy laser R&D which was, a result of modified ground rules, reoriented from 6.3A to 6.2, and $12M in nuclear monitoring which was reoriented from 6.1 to 6.2. The FY 1981 real growth is then 10 percent for 6.1, 8 percent for 6.2 and -1 percent for 6.3A.

II

II. POLICIES

A. Objectives and Goals

In recent years our national security has become increasingly dependent upon our military technological superiority which in turn is based on maintaining our technological lead time. To maintain this technological lead time, we apply three basic mechanisms within the S&T Program:

- o Real growth in funding our Technology Base;
- o Support to enhance and exploit our domestic advantage in commercial technology and our industrial base; and
- o Improved cooperation with our Allies.

The Soviet Union has long recognized the significance of the existing technology differential between itself and the United States, and the resultant impact on achieved military advantage. We dare not ignore the challenge issued by the Soviets. We have great strengths in meeting this challenge. We have the greatest technological capability and the strongest industrial base in the world. Our Allies in aggregate have an equivalent technological and industrial capability. It is upon these strengths that we seek to build.

The continuing overall objective of the DoD S&T Program is to:

> Maintain a level of technological supremacy which enables the United States to develop, acquire and maintain military capabilities needed for our national security.

For FY 1981 three specific goals have been identified in the DoD S&T Program in support of this basic objective:

1. Provide real growth in the Technology Base

The most essential function of the Technology Base is to provide the technological infrastructure which is so important for the steady, evolutionary growth of our military capabilities. It must be comprehensive and diversified enough to maintain our technological supremacy and lead time. As such, the Technology Base efforts require a high degree of funding stability from year to year.

The Technology Base must also provide the ability to recognize and capitalize on revolutionary technological developments. Laser guided weapons depended on application of diverse technical advances in lasers, sensors and integrated circuits. Our current efforts to make precision-guided "smart weapons" more autonomous and more independent of weather and battlefield environments likewise require the coordination of several different scientific and technical disciplines. Thus, we established a major thrust to consider and measure: the atmospheric and weather effects; target and background signatures; seeker technology; and guidance and control technology. It is anticipated that successful execution of the Very High Speed Integrated Circuits Program will provide impetus to the development of such precision-guided munitions.

2. Exploit the use of Advanced Technology Developments (6.3A) for more effective transition of technology to military systems

Our Advanced Technology Developments Program is designed to decrease costs by demonstrating useful military applications of technology and to

shorten the time needed to apply the technology to military operational and support systems. It does this by one-of-a-kind demonstrations which do not need to meet all the military specifications. It is a relatively inexpensive way to select from alternate technologies, to determine changes in applications which will make the technology even more effective, and to facilitate the definition of options to satisfy mission element need statements (MENS). Recent examples of 6.3A programs which were fruitful are the infrared search and track, Ada common programming language, active and passive seekers for antiarmor munitions, on-board oxygen generating system for forward-based aircraft, and propulsion advances for the MX ICBM.

- The passive infrared search and track system (IRST), jointly developed with Canada, is designed to detect antiship missiles. It has demonstrated a very high probability of designating missiles in a heavy clutter environment. The results of the advanced technology development program were successful and the Navy is now evaluating the type and number of ships that should receive the IRST.

- Some years ago we initiated an effort to standardize on several current high order languages and to develop a new language, christened Ada, to be used in our military embedded computers. These efforts have provided an opportunity for coordinated development of generic software independent of the specific computer employed, reduced duplication of support environments required and will provide greater interoperability among military systems in the future.

- The Air Force has advanced the state-of-the-art of both milimeter wave (MMW) and IR seekers designed to autonomously acquire and home on armor targets. This technology has transitioned into the Air Force Wide Area Antiarmor Munitions (WAAM) Program. The concepts selected for further system development involve two infrared seekers operating in the micrometer band and two millimeter wave seekers, one at 39 GHZ and one at 94 GHZ.

- The Navy has initiated pilot production of 60 on-board generating systems for aircraft crew oxygen. These pilot systems will be evaluated in the Marine's AV-8A aircraft. The 2000 hour capabilities of these systems will eliminate the logistics problems of supplying liquid oxygen to forward bases and will make oxygen servicing between flights unnecessary, reducing flight turn-around time.

- The MX missile propulsion system, as now conceived, will utilize several technological advances first demonstrated in our Advanced Technology Development Program. Among these are:

  - Physically tough hydroxy-terminated polybutadiene (HTPB) propellants;

  - Carbon fiber-reinforced, carbon matrix (C/C) materials that reduce the number of components; and

  - Expandable, nested nozzle exit cones.

3. <u>Expedite a selected set of technologies which are of prime importance for protecting technological lead time</u>

We have selected the following technologies for increased emphasis because of the potential they have for greatly improved military capabilities:

- Precision-guided munitions (PGM) capabilities in adverse weather and battlefield environments;

- Very high speed integrated circuits (VHSIC);

- Directed energy;

- Advanced materials;

- Manufacturing technology; and

- Embedded computer software technology.

We have concentrated our PGM thrust upon improved weapon performance in adverse weather and various battlefield environments.

We expect an unusually high return on investment in our VHSIC program. By funding the IC industry to attack problems of specific concern to the DoD (high-speed signal processing, nuclear hardening, and increased commonality), we expect to focus industry's attention and capabilities to meeting the reliability, capacity, weight, volume, and power dissipation requirements of the "on-board" and "embedded" computers and special processors required for advanced military systems. Since we first outlined the program and developed it in greater detail, the pervasiveness of IC technology in future weapon systems has become more evident. We may not be able to develop the PGMs, advanced radar systems, and space defense systems we need and envision without the application of VHSIC technology. Therefore, it is essential that we maintain or increase our lead over the Soviets.

In high energy lasers and particle beam technology, we may be at parity or perhaps even lagging behind the Soviets. It is evident that their efforts in these fields of directed energy are very much larger than ours, perhaps five times as large. We believe we have a well-balanced program that provides three fundamental objectives:

- It puts us into position to exploit these technologies when and if effective military applications are clearly defined;
- It enables us to evaluate the Soviet program realistically so that we can respond if a specific threat does develop in the future; and
- It is providing technology well worth the cost which can be applied to other fields of military importance.

Our thrusts in materials over the years have produced such important products as woven carbon fiber-carbon matrix (C/C) nose tips for our advanced reentry vehicles. With them we can continue to improve the accuracy of our ICBM warheads and also make them much more survivable should the Soviets renounce the ABM treaty and rapidly deploy simple ABM defenses. Our future thrusts are to develop the full property advantages of C/C composites, metal-matrix composites, and rapidly-solidified powder metal products to achieve greater strength and durability, improved thermal-mechanical stability, reduced weight, and increased temperature capability of aerospace and missile structures, components and propulsion systems. These advanced materials show special promise for significantly reducing our dependence on such critical strategic elements as chromium, cobalt, tantalum, titanium, and beryllium.

Much attention has been given to the lack of increased productivity and innovation within U.S. industry. Probably the single most effective program within the DoD to attack this problem and to improve our defense industrial preparedness is the Manufacturing Technology Program. We are working very closely with the Military Departments and with industry to further strengthen the program. We are striving to provide better visibility for active and completed projects and to better articulate the cost savings and productivity improvements which accrue to the DoD (and to American industry in general).

For some years it has been evident that, while the costs and capabilities of computer hardware have been improving dramatically, advances in computer software have not kept pace. Software costs have risen rapidly

relative to hardware costs which have declined even in inflated dollars. Today it is not unusual for initial software costs to dominate development costs of large military systems and to cost as much as much as 90 percent of total life cycle costs. A few years ago DoD began an effort to identify and rectify some of the more obvious shortcomings. We now are expanding our efforts in our Embedded Computer Software Technology Program to place design on a firm engineering basis, to improve reliability, and to reduce diversity and costs of that software unique to the most common and widespread computers i.e., those embedded within weapons or support systems.

B. Supporting Programs

The technical programs described in Chapter III represent some of the products of our efforts. However, the effective formulation, organization and implementation of the nations S&T base is dependent on the responsiveness and health of the DoD laboratory, university, and industrial infrastructures; the nation's productivity; on S&T information flow; and the innovative capacity of all sectors. There are several aspects of the national S&T effort, in our supporting programs, of great importance to the DoD effort:

1. In-House Laboratories - Management

The DoD in-house laboratory community continues to be a major component in the conduct of our research, development, and acquisition programs. The in-house laboratory system consists of 60,000 people with an approximate $5 billion annual budget and a capital plant value of over $4 billion. There are 73 activities ranging in size from about 100 individuals in a

specialized medical research facility to about 5,000 individuals at a major Naval weapons center.

We are continuing the process of establishing DoD policies leading to the removal of institutional management barriers inhibiting effective and innovative use of laboratory resources. As a result of the study on barriers to effective performance that we reported on in last year's statement, the Secretary of Defense established a DoD Laboratory Management Task Force composed of policy level personnel from the Services, the Defense Advanced Research Projects Agency, the Office of the Assistant Secretary (Manpower, Reserve Affairs, and Logistics) and the Comptroller. Working groups are now developing propositions for management improvements in the areas of personnel, procurement, and military construction. We plan to propose policy changes during the coming year that will offer the greatest potential for productivity improvement.

As documented in a government-wide GAO report to Congress on the Federal Laboratories, the personnel area offers the most significant challenges to management. Our pool of trained individuals is our most important resource. We must revitalize that resource both through vigorous personnel policies aimed at effective use of manpower resources and by extending opportunities in science and engineering to those groups in our population that are now underrepresented and underutilized.

Two of our Navy laboratories--the Naval Weapons Center and the Naval Ocean Systems Center--are taking advantage of the demonstration project provisions in the Civil Service Reform Act (CSRA) of 1978. When approved,

these laboratories will embark upon a multiple year experiment in a flexible professional performance recognition system.

Other initiatives being examined by our working groups are designed to implement management-by-objective (MBO) concepts of the Senior Executive Service embodied in the CSRA of 1978.

We will continue to work toward replacement of the present multiple, and sometimes conflicting, controls by a single control mechanism that can govern internal laboratory operations and costs. We find continued use of manpower ceilings in addition to grade level constraints is counter-productive and demoralizing to the work force. We desire mechanisms that will control internal laboratory operations and costs, that give laboratory management flexibility in executing tasks, and that make management accountable for its actions. We are confident the efforts of the DoD Laboratory Management Task Force will provide some workable alternatives to present procedures.

2. <u>Manufacturing Technology</u>

The Manufacturing Technology Program (MTP) is an aggressive DoD initiative to exploit innovative manufacturing concepts which show potential to reduce materiel acquisition costs and to improve industrial productivity. This primarily procurement-funded program invests "seed money" in feasible new generic technologies which have not yet been reduced to practice on the factory floor.

DoD would like to rely completely on the private sector for such developments. However, the unique nature of some defense requirements, and the

growing obsolescence of some government owned production facilities require DoD technology investments to bring about timely productivity improvements. By investing "seed money," DoD is able to reduce both the technical and financial risk of first case application. Once demonstrated, the technology is made available to the entire production base, and individual firms are more willing and able to implement the new approaches in a competitive environment.

MTP projects lead to such goals as cost reduction, reduced lead time, improved yield, improved quality and reliability, conservation of critical materials, improved safety, and reduced environmental pollution. Manufacturing Technology is a highly pervasive field and the results of DoD projects are often also applicable to the private sector. Thus, the MTP not only provides direct DoD benefits but also provides spin-off benefits by improving the nation's productivity position as a whole. Specific examples of recently completed MTP efforts are:

- Ships Beam Bender. A 37 ton prototype machine is capable of bending beams for the ribs of a ship to an accuracy of 1/4 inch. The beams can be up to 23 inches wide and 42 feet long. It will reduce the cost per bend from the current $200 to $12 in addition to providing repeatable bends which will significantly reduce ship fabrication costs.

- Precision Casting of Titanium. A precision, near-net-shape, centrifugal titanium casting technique has been demonstrated which will replace a two-piece, forged and welded component in a turbine engine. The new process (1) improves material use, (2) reduces machining, welding and tooling costs and, (3) cuts lead time. This improved productivity adds up to a savings of over $900 per engine.

- <u>High Resistivity Silicon</u>. A tri-Service project has established the technology to produce 2,000 grams/month. High resistivity silicon is an essential element of infrared seekers in precision guided munitions. The only viable source for the material is off shore. This process also reduces the cost from $28 per gram to $10-15 per gram. The domestic source is now being scaled up to meet DoD's near term needs.

- <u>Pollution Abatement</u>. A TNT production line uses and exhausts over three million gallons of water daily. A new water recycling process reduces the daily water requirement by 96 percent In addition, the $632,000 invested eliminates the need for an $11 million pollution abatement facility. It is applicable to 17 additional TNT lines.

- <u>Metal Matrix Composite Production</u>. A principle bottleneck limiting the application of high strength, low weight metal matrix composites to weapons systems has been the lack of a production base. A $600,000 investment has increased the graphite fiber reinforced, aluminum-metal-matrix wire production capacity from 100 to 3,000 lbs/year. Also, the new process reduces the cost from $3,000 to $250 per pound.

- <u>Fiberglass Radomes</u>. A $116,000 investment has reduced the cost of the Phalanx search and track radomes from $6,000 to less than $600. Approximately $400,000 cost avoidance has already been accrued and an additional $4 million is expected through 1984.

MTP emphasis during the coming year will be on improving program management and payback and on selecting projects of greatest need and return on investment. Also, we will be stressing the need for both an implementation plan <u>prior to investment</u> and a post project analysis to track and document project benefits. Technology transfer/diffusion efforts will be continued by holding end-of-contract demonstrations and by publishing of program plans and project results for the benefit of the production community.

A tri-Service data base to be administered by the Defense Technical Information Center is being developed to assist in handling the large

volume of information necessary to manage the MTP and to report results to the defense industrial base and private sectors. It will include information on all planned, active, and completed projects.

3. Independent Research and Development (IR&D)

We have maintained a substantial technological lead over the Soviets not only through our funded S&T Program but also through the Independent Research and Development (IR&D) programs conducted by our industry. While it is difficult to get precise information about the Soviet Union's S&T Program, we know that their leadership gives it a very high priority and funds it accordingly. However, our IR&D effort, for which the Soviets have no counterpart, partially compensates for the large scale of the Soviet program.

The IR&D program is structured by the companies themselves to advance technology in ways they believe will strengthen their ability to compete and become more efficient in the development and production of high technology systems. Therefore, the IR&D effort is a crucial DoD investment in maintaining effective competition, increasing acquisition efficiency, and in sharpening the responsiveness of industry to DoD needs. IR&D is effective because it promotes independent initiative and harnesses the competitive and innovative forces of the free enterprise economy that have served us so well in the past.

Generally, we are satisfied with the IR&D effort, but there are a number of issues that merit continued attention. These are concerned with the need to ensure maximum benefits to DoD in a fashion which does not interfere

with the independent nature of IR&D. We are also interested in more effective coupling and integrating of the country's IR&D investment with that of our DoD S&T Program.

We have completed a correlation of 1979 IR&D efforts with the funded S&T programs, (6.1, 6.2, 6.3A), which permits comparisons of relative IR&D/S&T efforts in basic research, in 22 generic areas of science, and in 26 areas of technology. This information has been distributed to the cognizant professionals on my staff and to the appropriate Assistant Secretaries of the Services for use in their program planning.

In a further move to improve the IR&D function, We are working with the Deputy Under Secretary of Defense for Acquisition Policy to devise for the IR&D Policy Council guidelines which incorporate my technical responsibilities. These include chairing the Technical Evaluation Group, surveillance of the IR&D data bank, development of policy for the technical aspects of IR&D, coordination with Acquisition Policy and the Cost Accounting Standards Board, and representing OSD to industry on the technical opportunities and requirements of IR&D.

Finally, we are conducting studies to develop, in concert with other elements of OUSDRE and IR&D experts, additional management initiatives for amplifying the collective benefits to the DoD of both the IR&D and our funded S&T programs without compromising the independent character of IR&D.

4. International S&T Cooperation

Consistent with our objective of cooperating with our Allies, we are

continuing our close S&T international relationship through two major programs. These are the NATO Defense Research Group (DRG) and The Technical Cooperation Program (TTCP). I have been designated the U.S. Principal on these programs, and it is my intention to develop initiatives within the participating countries which promote strong S&T information exchanges and collaborative endeavors leading to a stronger and more viable technology base for the alliance as a whole.

During 1979 export control functions were reorganized to reduce fragmentation within OSD and to strengthen both the policy and operating aspects of export control and responses to licensing requests. Under this reorganization, responsibility for nine primary functions is now under the Deputy Under Secretary of Defense (International Programs and Technology). These are: (1) processing munitions cases; (2) processing Allied strategic trade cases; (3) processing U.S. strategic trade cases; (4) identifying critical technology; (5) managing international cooperation in research, development, and acquisition; (6) approving data exchange agreements and information exchange projects; (7) reviewing S&T agreements; (8) reviewing technical implications of foreign military sales cases, reciprocal procurement memorandum of understandings, etc; and, (9) reviewing international implications of industrial and information security policy as it pertains to technology control.

The underlying principle in the DoD for handling technology trade matters is that we draw on all the resources in DoD--the Services, OUSDRE, Defense Agencies, etc. In addition, we will be supported by industry

through both voluntary and contracting relationships. My S&T staff will continue to be an important part of this team effort and will provide direct consulting and case-review support upon request of the new office for International Programs and Technology.

5. Scientific and Technical Information

The major accomplishment in the DoD S&T Information Program (STI) in the last year was the redesignation of the Defense Documentation Center (DDC) as the Defense Technical Information Center (DTIC). DTIC has been given major new responsibilities in addition to maintaining DDC's previous documentation services. Some of these are:

- Improved and individualized services to R&D managers in the Pentagon.
- Support to OUSDR&E in managing and coordinating the overall DoD STI Program.
- Control of nine DoD-supported information analysis centers.
- Establishment of an R&D program designed to improve the efficiency and effectiveness of DTIC's own program and that of the DoD STI program.
- Enlargement of data processing capabilities to support increased DTIC services to users, OUSDR&E, and other OSD organizations upon request.

A Steering Group is being established with membership from the Defense Logistics Agency (DTIC's parent group), OUSDR&E, DTIC, OSD Comptroller, and the Military Services to provide assistance during the reorganization and transition period.

New actions planned for next year will require that we:

- o Strengthen the DoD STI focal point network.
- o Upgrade and update DoD directives and instructions that pertain to technical information.
- o Encourage the reduction of paperwork by requiring fully electronic inputs into the DTIC data base.
- o Make available to R&D managers and investigators on-line access to many new STI bibliographic and numeric data bases on the market.
- o Improve quality and utility of OUSDR&E data bases maintained at DTIC.
- o Cooperate with DARPA in developing and implementing new information technology to improve DTIC's and OUSDRE's STI capabilities.

6. Global Weather Support

We are developing and employing within DoD a number of vastly dissimilar weapon systems. One common factor governing all of the systems, however, is that they must operate in the real world, influenced by the effects of the environment in which they are employed.

The Chinese author Sun Tzu wrote in 500 BC:

> "And therefore I say: know the enemy, know yourself; your victory will never be endangered. Know the ground, know the weather; your victory will then be total."

This statement is as true today as it was 2,500 years ago. Indeed, with the advent of modern weapon systems, weather (meteorological, oceanographic, etc.) conditions become more critical. Consequently, we must maintain a military weather support structure commensurate with our global responsibility and CONUS infrastructure.

The weather support programs within DoD are structured to use the total Federal program as a base upon which we can build to meet our special military needs. To ensure maximum coordination of the military and civilian program, we have assigned two officers as full time members of the Office of the Federal Coordinator for Meteorological Services and Supporting Research.

The equipment for supporting our CONUS bases has much in common with that required to support the weather facilities of the National Oceanic and Atmospheric Administration (NOAA) and the Federal Aviation Administration (FAA). We are currently participating in a Joint Systems Program Office for the development and acquisition of a new, advanced Doppler weather radar system which will replace the aging weather radars of all three organizations. This common radar will permit significant economies in training and logistics in addition to providing a major enhancement to our ability to detect, track, and predict severe storms. We are also exploring the same joint arrangement for the development and acquisition of automated observing systems which could have significant implications for future manpower and basing structures.

Although the equipment for our CONUS bases is critical to flight safety and resource protection in this country, the <u>raison d'etre</u> for the weather support structure within DoD is to provide operational information to the combat forces. Last year, our office conducted a review of the weather sensitivities of the various weapon systems and examined the mechanisms

for ensuring that these weather factors are included in all phases of the life cycle of our systems. We have continued to stress the understanding of adverse weather and man-made obscurants as they interact with our visual and infrared guided weapons. The Army is in the final engineering development of meteorological sounding systems for support of the field artillery. The Navy is developing equipment which will convert the observed environmental conditions onboard ships directly to weapons effectiveness information for the operational decision maker. The Air Force is developing techniques and equipment to obtain weather information from enemy controlled areas for application to the modern battlefield.

In summary, we are committed to a vigorous weather support structure within DoD, one which is responsive to the entire spectrum of needs--from that of the system designer through that of the battlefield commander.

7. Energy RDT&E

The major thrusts of the DoD Energy Program are directed toward applications and, when necessary, "user-oriented" developments of specific technologies that will enable DoD:

- To encourage, in cooperation with DoE, the commercialization of a domestic synthetic fuels industry capable of producing mobility fuels for military use;
- To utilize domestically produced synthetic fuels and alternate conventional fuels in mobile military systems;
- To reduce overall energy consumption through efficiency improvements without compromising flexibility, readiness or performance;
- To achieve an adequate degree of energy self-sufficiency for military installations through reduced dependence on petroleum fuels;

- o To develop an energy self-sufficient remote site capability; and,

- o To develop a family of military engines and power generation equipment with multifuel capabilities to allow them to operate on a broad range of both synthetic and conventional fuels.

Within the past year we have improved the management functions of the DoD RDT&E Energy Program by integrating it under a newly created Defense Energy Technology Policy Committee which I head. My office coordinates the DoD My Office coordinates the DoD synfuels requirements with the Department of Energy. We have has completed negotiations with the Department of Energy to purchase over 42,000 barrels of crude shale oil obtained under DoE R&D programs. This crude will be transported to existing industrial facilities to be upgraded to preliminary DoD specifications and tested by the Military Departments in their vehicles. Future synthetic fuel supply and delivery schedules to support this testing program are being planned through joint DoD and DoE coordination.

All three Military Departments have also:

- o Initiated test programs to evaluate the performance of shale-based fuels on their equipment;

- o Evaluated the extent to which synfuel specifiations must be rewritten, simplified, and/or modified to meet the operational needs of mobility equipment;

- o Initiated work in the development of engines capable of operating with a broad range of fuels.

In the area of conservation, the Navy has developed a paint that inhibits the growth of barnacles on the hulls of ships, resulting in

reduced drag and a 25 percent increase in cruise efficiency with a resulting increase in the time between maintenance periods. Basic Navy studies of hydrodynamics have resulted in more streamlined hull bodies that are now being incorporated in model designs. These changes should result in more efficient fuel consumption by Naval vessels at normal cruising speed without degradation of high speed performance. Air Force flight dynamic studies have evolved flight profiles that reduce energy consumption and enable the aircraft to achieve extended range and increased performance.

In cooperation with DoE, the Army Corps of Engineers has developed the BLAST (Building Loads Analysis and Systems Thermodynamics) computer program which enables a facility to optimize the use of energy, select areas to maximize conservation efforts, and reduce consumption of fuel. This program is used by the other Services and civil organizations to augment their conservation activities. Other joint DoD/DoE programs are underway in exploring geothermal areas, solar energy, and biomass in order to reduce the fossil energy required to support a military installation or test facility.

The Fiscal Year 1981 request includes funds for a number of activities; a few are listed below:

- Component test programs and preliminary engine tests utilizing shale oil fuels prepared to current petroleum based fuel specifications will be completed. From the results of these tests and concurrent laboratory tests, interim specifications for shale oil based fuels will be developed. Full scale engine tests will be continued through FY 1981 to mid FY 1982 prior to operational evaluation tests on dedicated mobile equipments.

- o Work will be continued on multifuel engines (engines capable of efficiently operating on a wide range of fuels, i.e., gasoline to diesel). The engines should also function on liquid fuels from a wide range of sources (petroleum, shale, and coal). The new T700 helicopter engine is a forerunner of this kind of engine and has been qualified to operate on JP4, JP5, and JP8.

- o DoD will continue to work with DoE on joint DoD/DoE conservation programs where DoE energy savings concepts will be tested and evaluated at military installations. The organic Rankine cycle bottoming system to be tested at the Naval Air Station, Bermuda, and co-generation at Sewell's Point are examples of such programs. Additional agreements with DoE have been completed or are in process which will demonstrate energy conservation concepts at other installations.

III. SELECTED MAJOR FY 1981 TECHNICAL PROGRAMS

I will focus here on some of the technical programs in the S&T program which are of particular significance and illustrate the importance of the FY 1981 planned efforts.

A. Research

The importance of basic research to the DoD was emphasized by the President in his March 1979 message to Congress and by Secretary Brown in a May 1979 memorandum to the Military Departments. The following steps will ensure implementation of that policy.

In FY 1981 we intend to focus the real growth increase into areas that will enable today's scientific opportunities to be converted to the technologies applicable to tomorrow's military requirements.

To ensure more effective and expeditious return on our research investments, we are encouraging the development of new approaches to research management. Prominent among these is the promotion of cooperative programs among universities, in-house DoD laboratories, and industry in order to shorten the time for transitioning academic basic research accomplishments to applied research and development. Another management initiative involves the encouragement of multidisciplinary programs (cluster programs) focused on complex DoD problem areas and the phase-out of less than critical efforts. In addition, qualified military officers are being actively sought and assigned to more fully acquaint the research offices with user requirements and vice versa.

To develop a stronger awareness among the nation's top scientific and engineering talent in subjects of long-term DoD interest, we have initiated a series of Research Topical Reviews in which the scientific disciplines in the DoD programs are reviewed and discussed among leading scientists of Government, industry, and academia. To date, four such Topical Reviews, covering mathematics, physics, chemistry and materials, have been held. More than half of the approximately 500 attendees at each meeting are from the academic community, about twenty five percent are from industry, and the remainder are from Government laboratories. These conferences are expected to renew and revitalize the DoD links that had previously existed with academic and industrial scientists. Twelve such meetings are scheduled through calendar year 1982.

Beyond the need for stronger ties to the academic community, many of the new DoD thrusts require large, coordinated efforts which involve several disciplines. Accordingly, as indicated before, I have encouraged the Services to place greater emphasis on multidisciplinary cluster programs in the participating universities. In these programs, the direction and coordination is provided by designated and informed top scientists who serve as academic project managers. The emphasis on multidisciplinary research is a necessity in modern science and technology.

Progress was made in reducing administration by initiating, on a two-year basis, the use of one page simplified contracts for research with

universities and nonprofit organizations. This is the first time that there has been a DoD-wide, uniform, simple contract for supporting research.

The defense mission is broad and the research interests are diversified. The past four year increased budgets have resulted in many accomplishments, some potentially of high payoff. For example, the DoD support of the proof-of-principle demonstration of a free electron laser has created an intense interest in the high energy laser and pulsed power R&D communities. Simply stated, it has the potential of providing an efficient, easily tunable (up to the ultraviolet region) intense beam of coherent radiation. Additional examples include;

- Underwater Acoustic Transducer Material. Capabilities in this field have been markedly advanced by the discovery of a broad class of composites. They consist of patterned arrangements of piezoelectric ceramics within a polymer matrix. Figures of merit sixty times those of current hydrophone materials have been demonstrated. These new candidate sonar materials have also been made in neutrally buoyant form; size and shape variations are not fabrication limited. In addition, they offer improvement in mechanical shock resistance over currently used transducer materials. Another important feature is their compatibility with integrated circuit technology, allowing for impedance matching to required cabling. The suitability of these materials for towed and conformal arrays seems encouraging, and is to be evaluated in the next several months.

- Highly Parallel Arrays. While digital computers have been decreasing in size and cost at a rapid rate, the increase in speed has been modest. DoD research has recently demonstrated how to divide the computational load for many important mathematical operations between very large numbers of very simple computing modes with no overhead cost. Many previously totally intractible problems are now solvable. This work will result in improved sonar and radar surveillance, image processing, pattern recognition, weather prediction, and computer generated imagery. It will make the VHSIC results even more potent.

- Absolute Gravity Measurements. An instrument using an atomic clock and laser length standards was developed to measure absolute gravity very accurately. Using a satellite borne altimeter the shapes of the ocean's surfaces are being measured. Both of these efforts aid in improving missile guidance by the reduction of geodetic and gravity errors.

- New Procedure for Measuring Toxicity of Chemicals. A unique human cell structure system has been developed to investigate toxic and carcinogenic effects of chemicals used in missile propellants. This procedure will permit better extrapolation of laboratory findings to actual effects in man and should reduce the costly current toxicology studies now required by regulatory agencies.

- Rapid Cooling Materials Processing. Using the rapid cooling techniques inherent in powder metallurgy, aluminum alloys have been developed that have strengths at 450°F similar to those of state-of-the-art alloy at 250°F. This would allow substitution of aluminum alloys for titanium alloys in the 450°-650°F temperature range with a possible 80 percent reduction in cost and 15 percent reduction in weight. Such a substitution would greatly decrease our dependence on a scarce material.

Among the major investments to be made in the FY 1981 program are:

- Microstructure Electronics. Techniques have been developed for on-chip integration of circuits. This may lead to fast, precise signal processing on single chips. It may also be useful in processing data from multiple targets. Work on high resolution X-ray lithography will be extended with demonstration of devices with submicron features. Liquid phase epitaxial films are being investigated for applicability to high speed, low power memory and logic circuits. The physics and chemistry of ultrasmall devices (50 Angstrom to 500 Angstrom) is being studied to develop the base for novel devices--a generation beyond VHSIC.

- Generation and Detection of Radiation. A relativistic electron beam which passes through a rippled magnetic field has been shown to be an intense source of millimeter waves. This could be the basis for short-range radars for night and adverse weather applications. A novel hydrophone has been developed which uses an optical fiber as the sensing element. Extremely high sensitivities can be obtained by sonically coupling to a long fiber. An intense beam of pulses from a high frequency

transmitter may be used to modulate the flow in and out of the auroral atmosphere. The extremely low frequency radiation obtained in this way may provide an alternate communications link to submarines.

- Propulsion. An electromagnetic gun in which a projectile is propelled by a magnetic field has many advantages. It would have no tube wear, flash, or smoke. Research on magnets, power sources, and projectiles is expected to provide the basis for design of a prototype. Research on superconducting materials has made possible the design of efficient electric drives and magnetohydrodynamic power generators for ship propulsion. Investigation of marked boundary layers indicates the possibility of drag reduction available to water vehicles if rejected heat from the propulsion system is used to warm the laminar flow portion of the hull. This is one of a number of promising ways to reduce hydrodynamic drag.

- High Performance Materials. Tailoring of properties through control of the atomic structure is leading to a host of novel materials, ranging from new alloys and compounds to materials having unusual electrical, optical and magnetic properties (intercalated graphite, ion implanted silicon, and amorphous silicon). Fabrication of ball bearings from silicon nitride will afford lifetimes several times greater than steel. An investigation of continuous nucleated thermochemical process for coating with silicon carbide produces a surface having fine grain structure and great hardness. This will be applied to high temperature protective coatings for turbine components.

- Combat Environments. Research with cloud physics chambers has enabled the measurement of large scale atmospheric processes, the study of crystal growth, charge separation, and energy release. From these measurements, information for estimating the degradation of laser and microwave transmissions will be obtained. New radar, image, and signal processing techniques will form the basis for all weather detection of slow moving targets concealed by foliage or embedded in a severe clutter environment.

- Protection of Personnel. Research on fibers and characteristics of semipermeable clothing materials is expected to result in much better protection in nuclear-biological-chemical warfare.

- Scientific Equipment Upgrade. Modern complex equipment is necessary to allow our researchers to work at the very forefront of science and compete more effectively with their foreign counter-

parts. This includes such items as: modern accelerators, fast computers, scanning electron microscopes, spectrometers, and advanced laser facilities. Leveraging our support with that of the National Science Foundation, the Department of Energy, and the National Aeronautics and Space Administration, we plan to provide more state-of-the-art equipment to maximize our payback.

B. Very High Speed Integrated Circuits (VHSIC)

The objective of the VHSIC Program is to provide dramatic improvement in our capability for high speed, high throughput signal and data processing of the type desired for military systems in the mid-1980's and beyond. This program seeks to accelerate the development of new technology for integrated circuits (IC) and to closely tie the resultant products to high priority military systems requirements. The VHSIC Program was initiated in order to:

- realize the performance and life cycle cost advantages that commonality in signal processing functions can provide;
- accelerate IC technology advances and direct its end products toward DoD needs; and
- increase our lead in IC technology over potential adversaries.

Initial VHSIC contract award decisions were made in February 1980. The program will extend through FY 1986 with an average annual funding of about $36 million for a total of about $210 million. The program is a fully coordinated effort, executed through the Military Departments with overall management direction from my office. The program will be carried out principally through industrial and university contracts. The program is structured to encourage innovation from the private sector.

To meet its goals, the program has been divided into three consecutive phases (Phase 0, I, and II) and an additional effort termed supporting technology, which will run concurrently with the consecutive phases. The end goal of the entire program is to achieve a capability for advanced systems performance based on making available large scale, high speed ICs suitable for use in military environments.

Phase 0 is currently underway on multiple contract awards. It includes system and subsystem analysis, partitioning studies, optimal silicon chip design layouts, computer aided device modeling and experimental fabrication and testing of designs, layouts and processing techniques. It will result in a definitive plan in the form of a proposal for Phase I by each contractor.

Phase I will select from the results of Phase 0 those projects which give promise of the greatest potential for military systems. Phase Ia will result in the establishment of a pilot line production capability for VHSIC with 1.25 micrometer feature sizes. It will also demonstrate the feasibility and applicability of design tools and simulation aids, and additionally the basic principles of design/architecture/software/testing (DAST) and packaging. Phase Ib will consist of initial efforts to extend the state-of-the-art of IC fabrication and DAST to submicrometer feature sizes and associated higher gate densities.

Phase IIa will provide system demonstrations of silicon chips designed to 1.25 micrometer rules. Phase IIb will attempt to extend the state-of-the-art of IC fabrication and DAST to submicrometer feature sizes to obtain

higher gate densities and higher signal speeds. The end goal is to establish a pilot production capability to fabricate IC with 0.5 micrometer feature sizes.

The Technology Support Phase will run in parallel throughout the program with periodic requests for proposals in areas where technology needs appear critical. Approximately thirty percent of VHSIC funding will be applied to this part of the program.

In response to the Report of the Joint Congressional Conference on the DoD Authorization Bill, a VHSIC Program Office has been established under my cognizance to provide overall management of the VHSIC program. A management plan was structured to:

- couple DARPA and DNA programs with VHSIC efforts;
- foster coordination with the intelligence communities in order to track U.S. technology implementation as well as technology lead over potential adversaries.

The VHSIC program will be contractually executed through the Military Departments.

In order to control the export of developed technology, the program, where appropriate, will be placed under the International Traffic in Arms Regulations (ITARS).

In order to encourage rapid diffusion of VHSIC technology throughout the U.S. semiconductor industry, second sourcing clauses will be part of the Phase 0, I, and II contracts. These will require contractors to enter into licensing arrangements for the parts of their VHSIC manufacturing system (including software) developed under this program.

The National Material Advisory Board will determine the specific impact(s) of the VHSIC program on the general U.S. industry resource base. It is believed that since the semiconductor industry spends approximately 10 percent of its annual sales on R&D ($300 million), and since the VHSIC program will be about 10 percent of this amount ($36 million), industry can redirect ongoing R&D efforts to focus on VHSIC program goals with minimal interference to commercial development.

C. PGM Capabilities in Adverse Weather and Battlefield Environments

Precision Guided Munitions (PGM) provide DoD with the potential for major revolutionary advances in combat effectiveness. Proper exploitation of PGM technologies can significantly increase our ability to counter numerically superior forces and to deploy significant firepower economically.

Because PGM's currently depend upon transmission of visual or infrared energy through the atmosphere, they are more sensitive to adverse weather and battlefield environments than are conventional weapons. Two years ago we initiated a major program for studying the atmospheric effects on our current and projected systems. It included activities ranging from modeling weather characteristics to specific tests in realistic battlefield conditions such as smoke, dust and fog.

As important and powerful as the present systems are, technology must be developed to mitigate the adverse weather effects. This focus on adverse environments has caused us to emphasize efforts in two directions.

First, we have emphasized technology development in the transparent windows of the electromagnetic spectrum, primarily millimeter waves (MMW). The development of cost effective MMW missile seekers has been constrained by poor resolution, the lack of maturity of MMW electronic devices, and our lack of knowledge about target and background signatures. We need to continue to advance the state-of-the-art in small solid state electronic devices and signal processing techniques which will enable the detection and recognition of military targets at usable ranges. We recognize the long range acquisition problem which exists with passive MMW systems and have identified dual mode techniques (active/passive) which will allow relatively long range acquisition of targets in the active mode and then automatically hand over to a passive mode to obtain hit-to-kill accuracy. A major effort is underway to characterize targets in a cluttered background and to develop an understanding of target/background interaction. This knowledge is essential to the development of effective acquisition and homing algorithms which will allow an autonomous seeker capability.

Secondly, emphasis in the S&T community is being directed at PGM systems which operate in the infrared (IR) region. Adverse weather capabilities in this area are limited. However, the use of multiple detector arrays can make IR PGMs operate much better in degraded environments. The range capability, or sensitivity, of IR seekers is related to the number of detectors used. Recent advances in imaging IR focal plane arrays will provide orders of magnitude increases in the number of detectors in a seeker with a concomitant improvement in seeker sensitivity. We may be

able to implement this technology in modular improvements to our PGM's.

D. Chemical Warfare and Chemical/Biological Defense

The Soviet/Warsaw Pact forces continue to maintain a superior capability to survive and operate in a toxic environment.' Warsaw Pact doctrine clearly envisions the employment of chemical weapons in a conventional or tactical nuclear conflict when they believe a significant tactical advantage can be gained.

To meet this threat, we are implementing a major procurement and RDT&E effort, since our forces are not yet fully prepared to survive and operate in a chemical attack. We have recognized this deficiency in DoD and have launched an intensive effort to equip and train all forces, including rapid deployment forces (RDF). We plan to provide an adequate defensive posture in the near term for Army and Air Force personnel, including the reserve and augmentee forces which would be required for a European conflict. Planning to improve the RDF includes acceleration of procurement programs for existing alarms, masks and overgarments, as well as shortening the development cycle for critical items. These actions combined with an adequate training program to utilize available equipment will lead to a sustained operational capability in the longer term.

We have initiated S&T programs to develop new and improved materials for both overgarments and protective masks and improved prophylaxis and therapy with less side effects. Exploratory efforts in agent detection and identification and decontamination materials are being enhanced. The advanced chemical agent alarm (ACADA) and the new water test kit will

move into Advanced Development. A new effort is directed toward simplified battlefield shelters for collective protection. Engineering development programs include continuing development of the improved individual protective mask and expanded programs for collective protection of vehicles and training systems. Engineering Development is being initiated on a scanning infrared remote chemical alarm. Operational and development testing of the first biological detection and alarm system is nearly completed. A major effort is directed toward decontamination fluids and dispensing apparatus which will facilitate decontamination of sensitive equipment, personnel, and large areas; thereby improving mobility and logistics.

The United States has engaged in intensive bilateral negotiations with the USSR for the last three years toward a comprehensive, effective, verifiable agreement. These negotiations continue, and although some general agreements have been reached, major differences exist While these continue, world events including the use of chemical warfare in Laos and the reported use of chemicals in Afganistan have emphasized the continued need for a credible retaliatory stockpile. Our deterrent stockpile has continued to degrade and become obsolete; thus, limited efforts have been maintained in the development of binary munitions to provide the necessary technology base in the event modernization of the deterrent stockpile is required. A warhead for the multiple launch rocket system (MLRS) and a 155mm projectile to deliver an intermediate volatility nerve agent are in Advanced Development. Binary munitions, while modernizing our deterrent/retaliatory stockpile, would also provide

significant safety advantages in manufacturing, storage, surveillance, transportation and disposal operations. Binary facility design as well as maintenance and surveillance of the existing stockpile is continuing.

E. Materials and Structures.

In the past our Materials and Structures Program has emphasized cost reduction and performance improvement with attention paid to conservation only when associated with cost reduction. In FY 1981, with our growing dependence on foreign sources for raw materials, greater emphasis will be placed on substitution and conservation. We will stress technology to achieve more independence in the area of strategic and critical materials. In both of the major thrusts which were discussed last year, viz., erosion resistant carbon/carbon (C/C) composite thermal protection materials for strategic missile reentry vehicles and metal-matrix composite (MMC) structural materials, the basic starting materials are predominantly obtainable from domestic sources.

The coordinated Navy and Air Force program in erosion resistant (C/C) composite materials is directed toward improving the survivability and accuracy of advanced reentry vehicles under adverse atmospheric conditions caused by severe weather and/or nuclear bursts. Our goal is an initial flight test by the end of FY 1982. A number of in-house and contractual efforts are investigating innovative concepts ranging from improvements in the construction and processing of C/C materials to changes in the content of these composites.

The technological base that the DoD has built in the area of C/C composites is being further exploited by the gas turbine community. The viability of these composite materials for application to the hot sections of gas turbines is being investigated by the Navy and Air Force. In addition to the performance gains that can be accrued because of the high temperature capabilities of C/C composites, their domestic availability and potential low cost could make them attractive alternates to the high cost gas turbine superalloys. Inasmuch as these superalloys contain appreciable amounts of cobalt and chromium, for which the U.S. is almost totally dependent on imports, the development of C/C for this application could contribute substantially towards relieving U.S. dependency on foreign sources.

The tri-Service/DARPA thrust program for the development and application of metal-matrix composite (MMC) materials for a variety of military applications is proceeding as planned. A number of contractual and in-house efforts have been initiated in the areas of:

- o Helicopter transmission housing and portable bridging components (Army);
- o Structures for strategic missiles, mines and torpedoes, and tactical missiles (Navy);
- o Airframe and gas turbine components (Air Force); and
- o Satellite components (DARPA).

In addition to these applications, MMC materials appear to show promise for an ever widening range of applications such as laser mirrors, lightweight gun mounts, submarine propellors, and antennae. One of the early

results emerging from this program is the development of reinforced lead grid materials for submarine batteries. If this development proves successful, it can result in lengthening the submarine battery replacement cycle from five to ten years, thereby aligning it with the nuclear core replacement schedule and reducing maintenance costs appreciably.

Another significant outcome of our early work in this program is the potential for substitution of MMC for critical or long lead time elements such as chromium, cobalt, titanium, and beryllium. As an example, it has been determined that high modulus graphite fiber-reinforced magnesium alloy composites exhibit stiffness, strength and dimensional stability properties equivalent to or superior to those of beryllium at the same weight. In another case, a titanium sheet clad, graphite fiber reinforced aluminum alloy MMC material has demonstrated structural properties which are comparable to those of a solid sheet of titanium one and one-half times thicker. Yet, the composite uses only seven percent titanium; thus, this MMC can save as much as ninety-three percent of the titanium conventionally used.

Some other examples of accomplishments which illustrate the general philosophy of conservation are:

- Demonstration of the weight and cost-effectiveness of graphite fiber-reinforced resin matrix composites for use in aircraft and missiles. The current aircraft production (F-14, F-15, F-16, F-18) use of these materials has saved substantial quantities of the aluminum alloys which would have otherwise been used.

- Demonstration that net shape complex aluminum castings for aircraft and missile applications can be produced at about a third of the cost of conventionally fabricated parts and with savings of about 80 percent aluminum over forged parts.

We furthermore have initiated a tri-Service/DARPA planning activity in the new technology area of rapidly solidified metal powders. The objective of this new technology is to produce very high quality starting materials for new families of aluminum and titanium alloys as well as superalloys. Our current modest investments have demonstrated sufficient promise and maturity of this technology to justify initiating a major, long term financial commitment by the DoD to accelerate the development of these new materials. Moreover, this technology has demonstrated the potential for producing superior superalloys with only minor amounts of critical or scarce materials. This enhancement of our current program in this area is scheduled to start in FY 1982.

F. Directed Energy

A number of highly significant milestones in the high energy laser (HEL) program have been passed during the year. These achievements and their significance to planned future developments are summarized below.

- The equipment for the Airborne Laser Laboratory (ALL) has passed a number of intermediate tests, and demonstration of engagement of an air-to-air missile is expected in the near future.

- Fabrication and test of the laser and beam control equipment for the Navy's Sea Lite lethality verification program continues. Preliminary tests of components of the equipment have been successful.

- The Army's recent testing of a canister pump for a chemical laser system has demonstrated very efficient performance in terms of laser power output, run time, and amount of calcium used in the canister.

- A number of exploratory development efforts are continuing, looking at pulsed lasers, new optics configurations, and new lasing species.

- We are continuing our efforts to establish a National High Energy Laser Test Range at the White Sands Missile Range. Advertisement for bids for the military construction occurred in January of this year and contract award is expected in April. The facilities will support major demonstration programs of both the Navy and the Air Force, with Army participation. Advertisement of the Joint Short Range Test Facility on North Oscura Peak is expected this summer, with contract award this fall. In addition to program funds, there are $15.6 million of White Sands Missile Range institutional funds in the FY 1981 budget request which will be utilized in the development of the national test range.

In the particle beam area, fabrication of the experimental test accelerator, a DARPA program, has been completed, and initial tests are promising. Fabrication of the larger advanced test accelerator has started. Proof of principle experiments with the autoresonant accelerator, designed for the acceleration of protons, also appear promising.

During 1979, a task force of the Defense Science Board, chaired by Dr. John S. Foster, examined the High Energy Laser Program. While impressed with technological progress to date, the task force concluded that data do not exist at present to support a decision to begin development of any particular laser weapon system. System level field experiments are needed to determine the system performance requirements necessary to achieve a useful competitive application. The objective is to determine the highest military potential for high energy laser weapon systems. The

task force has made a number of recommendations for reorientation of certain technical thrusts, and for changes in the management structure of the DoD high energy laser program. Program modifications in response to these recommendations are being considered.

We are continuing to develop a management structure for the particle beam technology program to provide centralized technical management of this program, but without funding the entire effort in a single program element. We feel that it is essential to retain Service involvement in the program, at the staff level as well as at the laboratory level. In FY 1981, however, all of the major demonstration programs are funded in the DARPA budget. A memorandum of understanding has recently been agreed to by my office and the Director, DARPA, and approved by the Under Secretary of Defense for Research and Engineering, which provides for coherent management of the particle beam program. A Defense Science Board task force to examine the particle beam technology program has recently been formed, and held its first meeting on in February. A report is expected later this year.

G. Training and Simulation Technology

Military personnel are constantly challenged with increased requirements to monitor and control complex displays, interpret complex information available from various sensor systems and make decisions which will affect the safety of fellow troops. None of this is made easier by pressures to reduce the use of fuel and ammunition and to reduce the impact that military exercises have on the environment.

New technologies for training must keep pace with the advanced technologies built into our hardware systems. However, all of these issues are compounded by the increasing dependence of military forces on enlistees who may not meet high performance standards. We have the responsibility to develop their skills properly and quickly in order that those young people with underdeveloped skills may reach their full potential.

New and more effective methods of training are feasible by the increased use of simulators and of computer-based methods of instruction. Simulators permit us to train personnel to operate and maintain complex equipment in safety and with greater convenience, less wear and tear, and less expense than by the use of actual equipment. The use of powerful, portable computers will permit us to train individuals at their own pace, a technique not technically feasible in the recent past.

We have begun an active "technology watch" to determine which of the commercially available electronic games can be adapted to military use. We are currently adapting for military training TV-type arcade games that can speak and recognize voice inputs. These features are known to motivate people, thus being effective for training, while being less expensive than conventional devices. In addition, we are pushing steadily toward the demonstration and application of those readily available technologies specifically designed to solve military problems. An advanced system for training precision aircraft radar controllers was recently demonstrated. This prototype trainer uses computer voice recognition to provide individualized instruction to the student, thereby reducing both the need for

instructors and the total classroom time required to master the tasks. Simulators for hands-on maintenance training have advanced from technology demonstrations to actual trainers costing only 50 percent of those using actual equipment. By finding methods to simulate the noise of blank cartridges, we are saving thousands of dollars by avoiding the use of actual brass cartridge blanks when training with the recently deployed Multiple Laser Engagement (Training) System.

To manage such dynamic programs, we must have a data base system to track developments, oversee the multiple efforts of the Services and to ensure all users and doers that unnecessary overlap is not occurring. During last year's testimony, it was reported that we were working with the Assistant Secretary of Defense for Manpower, Reserve Affairs and Logistics to develop an information system which would allow OSD and the Services to jointly review, evaluate and manage the training and personnel technology programs. This has become a reality and will be placed in operation this year.

While most of our progress has been in terms of technology development and demonstration, we are making progress in introducing consideration of training and personnel issues early in the development cycle. Using the framework of the new procurement process and OMB Circular A-109, our laboratories are actively developing front-end analysis (FEA) techniques to determine training and human factors issues prior to Concept Formulation.

H. Embedded Computer Software Technology

Advances in software technology have not kept pace with the rapidly rising expectations generated by the dramatic advances in computer hardware technology. We are continuing our attack on software problems through a major new initiative focused on a few high pay-off projects. The major reasons are:

- o Software continues to be an increasingly important and increasingly expensive component of military systems, with estimates of DoD embedded computer software costs now running as high as $5 billion per year. Seventy to eighty percent of these costs are for support and evolution of software after initial deployment.

- o Advances in computer hardware technology are altering computer systems characteristics and expanding expectations for military systems so rapidly that most existing software tools will be of very limited use in solving the critical software problems of the mid-1980s.

- o DoD has specialized software needs that are not shared with most commercial and industrial applications of computers. These include requirements for automatic error recovery and fail safe execution, the need to simultaneously control a variety of sensors and activators, critical real time constraints, and extremely complex systems requirements that are continuously undergoing modification.

- o The approaching completion of the Ada common programming language standardization effort provides an opportunity for coordinated development of generic software, significantly reduced duplication of DoD software support environments, and greater interoperability among military software development and support environments.

The proposed software technology initiatve has two major parts. The first is aimed at the short term problems of realizing the potential benefits offered by the Ada common language effort which include more effective use of existing software technology, elimination of duplication in the

development and maintenance of widely used software products, and interoperability among the tools and aids used in the development and evolution of embedded systems software. This will require the establishment of a single focal point within DoD for coordinating the development, distribution and maintenance of generic software tools and common libraries. The second part of the program will be a longer-term effort to greatly improve the effectiveness of automated software technology to meet the military systems requirements and to complement the computer hardware of the mid-1980s. It will pursue tasks of very high potential and will emphasize responsiveness, timeliness, robustness, and reduction of indirect costs of software such as system downtime. The specific objective is to reduce software life cycle costs for embedded computer systems through automated software technology.

Progress along any one of several fronts would have significant impact. For example, a factor of 20 difference has been observed in the productivity of individual programmers. A factor of six improvement is common between the first and third implementation of similar systems by the same team. The ability to easily modify software systems without loss of reliability and efficiency would permit rapid response to changing threats which might arise from the introduction of new target signatures or new countermeasures in a tactical situation. The ability to rapidly prototype systems to test their usefulness under realistic conditions would avoid frequent situations in which a system is unused because critical characteristics were overlooked in its initial specification. And finally, it may be possible to automate

many of the mechanical tasks and thereby free the system designers to deal more effectively with the important problems of extending function and system effectiveness.

I. Insensitive High Explosives and Propellants (IHEP)

The IHEP program has succeeded in providing the focus and awareness which will improve the battlefield survivability of our major combat systems. For the next year the program will be carried out under the direct management of my office.

Tank gun ammunition with low vulnerability propellants should be ready for procurement during FY 1983. It is expected that advanced development of insensitive plastic-bonded explosives (PBX) can be completed by the end of FY 1982. Insensitive PBX's will be used in future missile warheads, air deliverable mines, an advanced bomb family, and an advanced lightweight torpedo.

In FY 1981 the formulation work for low vulnerability propellants will be completed and process development and characterization initiated. In addition, six candidate PBX explosives will have been screened, the best aluminized formulation and the best nonaluminized formulation selected, and the necessary documentation completed to permit the Army to develop production plant capabilities. The merits of nitroguanidine as an insensitive high explosive will also be fully assessed by the end of FY 1981.

J. Advanced Aircraft Technology

The principal objectives of the DoD Advanced Aircraft Technology Program are to: (1) reduce aircraft acquisition and support costs, (2) achieve

new and more effective operational capabilities, and (3) increase vehicle survivability.

A basic problem confronting the Aircraft Technology Program is that of transferring advanced technology into new aircraft systems. The major impediments are the long time required for technology to mature (up to 15 years in some cases) and the infrequent development of new aircraft systems. Our approach is: first, to focus on full scale flight demonstrations of the most promising technologies as they emerge, in order to reduce the readiness lead time; and second, to develop technologies which can be applied to existing systems on a retrofit basis.

In our FY 1981 program, major areas being pursued which reflect the approach outlined above, include: (1) the Advanced Fighter Technology Integration (AFTI) Program, (2) a nonmetallic composite helicopter fuselage, and (3) the circulation control rotor.

In the AFTI Program, the Air Force has demonstrated on a specially modified F-16 aircraft the capability to independently control aircraft translational and rotational degrees of freedom by employing independent control surfaces for each response axis. This results in unique maneuvering capabilities, including direct lift, direct sideforce and fuselage elevation, and azimuth pointing independent of flight path. These capabilities, along with the development of modern aircraft flight control technology (incorporating digital computational techniques), have led to task-tailored handling qualities such as improved weapon line-of-fire control, expanded weapon launch envelope, reduced weapon fire control time,

and increased maneuvering during weapon delivery. The anticipated benefits to future tactical aircraft include a 3-to-1 increase in air-to-air gunnery hits, and an improved missile exchange ratio. With regard to air-to-surface weapon delivery, a 2-to-1 accuracy improvement in weapon delivery during aircraft maneuvering and a 10-to-1 increase in launch aircraft survivability is possible.

As the AFTI technologies develop, they will be available for incorporation into existing aircraft systems. In FY 1981, development will be initiated to integrate the advanced flight control concepts with advanced fire control systems on an F-16 test bed aircraft.

The advantages of using nonmetallic composite materials in helicopter rotor blades have been well demonstrated in several Army and Navy programs. The Army has initiated the Advanced Composite Airframe Program (ACAP) to develop this technology for application to helicopter fuselage structures. The benefits for future helicopters to accrue from ACAP technology are: a 20 percent reduction in airframe weight; lower cost of ownership through reduced acquisition cost and lower maintenance requirements; reduced radar reflectivity; and improvements in damage tolerance, crashworthiness, laser hardening, and electromagnetic compatibility. These anticipated benefits will be validated by flight tests of a demonstrator aircraft with the first flight planned in mid-FY 1984.

The Navy initiated flight tests of the circulation control rotor (CCR) in September 1979. This advanced helicopter rotor concept originated in the Aviation and Surface Effects Department at the Naval Ship

Research and Development Center. A major step in technology transfer was accomplished with the initiation of the flight demonstration program in 1975 and the subsequent transition of the technology to the industrial community from the laboratory. The CCR employs a unique trailing edge boundary layer control scheme, resulting in a 25 percent increase in hover lift capability for the same installed horsepower and a reduction of rotor induced vibrations through implementation of higher harmonic control. Flight test of the CCR on an H-2 helicopter airframe will continue through 1981. The CCR has the potential for retrofit on existing helicopters.

K. Advanced Aircraft Propulsion Technology

The aircraft propulsion program efforts are aimed at providing technologies that are proven for application in the next major system prototype or engineering development program. Generally, payoffs accrue through efforts which reduce cost, improve reliability, and enhance durability.

- Cost Reduction. A major cost driver in aircraft propulsion systems is the number of parts; therefore, recent efforts in our technology programs have been aimed at reducing the number of parts in an engine. For example, the 1962 vintage, 17,000 pound thrust J79 engine in the F-4 aircraft had approximately 22,000 parts; the 1978 vintage, 16,000 pound thrusts F404 engine in the F-18 aircraft has approximately the same thrust but only 15,000 parts and weighs approximately 1,500 pounds less than the J79. On a thrust-to-weight basis the F404 is a 35 percent improvement over the J79. If one of the present ATEGG (advanced turbine engine gas generator) technology demonstrators is carried through development, the parts count would be reduced by another 20 percent and the cost/performance ratio further improved.

- Reliability. The Congress, aware of reliability problems in some of our advanced aircraft engines, has provided in the FY 1980 budget an additional $25 million to the Air Force and Navy to purchase more developmental hardware and to conduct additional testing. This additional hardware and testing time will provide a better future reliability assurance for these advanced components.

- Durability. Durability improvement in the turbine blades for the T400-WV-402 engine has been under investigation in our technology program. In 1979 single crystal turbine blades were manufactured and the rig was tested and successfully run for 100 hours in a T400 engine to evaluate improved durability over blades of current materials. Data analysis indicates a doubling of the current TBO (time between overhaul) of the T400 engine which is used in the Marine AH-1T helicopter. Plans call for initiating a 1000-hour certification program in 1980 with an operational use goal of late 1981.

L. Electronic Warfare

Electronic Warfare (EW) is concerned with exploiting the electromagnetic spectrum for friendly use and denying it to hostile use. The technology program is divided into radio-frequency (RF), electro-optic (EO) and acoustic EW. The techniques of energy generation and detection, the effects of the medium on propagation of the energy and the measurement of target and background signatures are unique to each spectral region. In each region, EW provides methods of countering surveillance, communications and weapons.

The S&T program in electronic warfare includes the following functional areas:

- Detection and location--which includes improved receivers, warning systems, and direction finding techniques to operate in a very dense signal environment.

- Jamming and deception--which includes programmable jammers, expendable decoys, and countermeasures against radars and missile seekers.

- Signal reduction and obscuration--which includes reduction of aircraft visibility, infrared signature reduction, smoke, obscurants and improved chaff.

- Counter-countermeasures--which covers spread spectrum techniques, frequency diversity and adaptive antenna methods.

- Exploitation and simulation--which includes the evaluation of the vulnerabilities of hostile weapon systems to countermeasures.

Recent accomplishments in the electronic warfare program include the following:

- We are developing jointly with Canada a passive infrared search and track system (IRST) designed to detect antiship missiles. The system provides complete azimuth coverage and passive surveillance of airborne and surface targets. The IRST has demonstrated a very high probability of designating missiles in a heavy clutter environment in both land and at-sea tests. Consequently, the IRST program has been transferred into engineering development. The Navy is currently studying its needs and evaluating the type and number of ships that should receive the IRST.

- Signal suppression through the use of radar and infrared absorbing chaff has been successfully demonstrated in a laboratory environment against radiation spanning the entire wavelength regime from far infrared to nearly microwave wavelength. The technical feasibility, operational utility and military worth of employing the absorbing chaff in a number of operations is currently being investigated within the Services.

- Considerable effort has been devoted to developing systems which detect electro-optical threats. Progress has been made in developing detection systems, such as laser warning receivers that indicate whether an aircraft or tank is being designated and detectors that indicate the presence of an incoming missile.

There have been two major shifts in emphasis in EW technology in the recent past. First, counter-countermeasure techniques have received increased emphasis in response to the severe and increasing EW threat. This is due

to the perceived weakness of our electronic systems in an EW environment and the recognition of the magnitude and sophistication of the Soviet threat. Second, the proliferation and increased effectiveness of electro-optical (EO) based weapon systems has caused a shift in emphasis from RF to EO technology. In particular, there has been a rapid growth in countermeasures to EO weapons such as missiles which employ IR homing, track by video contrast, and seeking of laser-designated targets. Furthermore, air defenses are using EO systems to back up radar-directed fire control.

The overall program has suffered in the past from the lack of realism in the training of our troops in EW. The lack of realism was primarily caused by the lack of a representative EW threat system and restrictions on the free play of EW in exercises. Efforts are being initiated to improve our EW training aids and to permit EW to become an integral part of tactics and operations training.

M. Medical and Life Sciences

The medical and life sciences research and development program includes three major thrust areas, each of which addresses a set of unique military problems. Each is supported by an array of scientific and technical expertise and by dedicated facilities, unduplicated in scope and emphasis in other Federal agencies. Each Service supports a medical research establishment which addresses its own specific medical research problems. The major thrust areas are:

- <u>Infectious Disease</u>. Infectious diseases endemic to areas of strategic importance pose a substantial threat to operational force missions. Infectious diseases have been the major cause of man days lost from combat in every war in history. Prevention of infectious disease is of particular concern in the context of Rapid Deployment Forces, which must be prepared to face exotic diseases worldwide on short notice. In the past decade there has been a serious deterioration in control of several diseases of military significance, for example, the resurgence of malaria with increasing drug resistance, the spread of Rift Valley Fever in the Middle East, and the emergence of several newly described virus agents in Africa. At the same time, the capabilities for and interest of American industry in R&D leading to drug and vaccine development for such diseases have eroded, as was pointed out by a recent Office of Technology Assessment report. In order to meet its world-wide commitment, DoD is maintaining its unique technology base. This year, our program, with the Army as lead, will continue animal tests of a promising new drug for the treatment of leishmaniasis, establish new screening methods for anti-schistosomal drugs, and begin testing a new vaccine against trypanosomiasis (sleeping sickness). Some new antiviral drugs will be tested for efficacy against Ebola, one of the new virulent infections from Africa. Initial steps in developing a vaccine against another, Lassa fever, have begun. We hope shortly to adapt the scrub typhus organism to cell culture, which will simplify our vaccine development attempts. The malaria program continues with synthesis of alternatives to primaquine for eradication of persistent malaria infections. Drug and vaccine development is necessarily a long-lead time process with, on the average, eight years elapsed from synthesis of a promising new lead to the completion of human trials. We are expanding our investment in drugs and vaccine development and in technology to address requirements for improved nuclear, biological and chemical defense.

- <u>Systems Health Hazards</u>. New weapons systems and changing combat doctrinal concepts place ever-increasing demands upon the human tolerances of the fighting man. The major part of our medical R&D program addresses enhancement of our war-fighting capacity by preventing the physiological hazards to health and performance associated with modern-day combat. Our research provides the biomedical data required for safe, efficient systems design; data on stresses of combat; and data needed for development of life support and protective

equipment and clothing. The products of these research efforts can be found in weapon systems designs which respect man's physiological tolerances and enhance rather than restrict his capacity to perform in combat.

The Air Force and Navy are working closely to develop new screening technology to determine the toxic effects of new fuels and propellants, with special interest given to shale-derived fuels. The Army is concerned with toxic effects of new battlefield smokes and obscurants. Our programs in the biological effects of electromagnetic radiation (EMR) is increasing their emphasis on low-level, long-term effects; we will shortly initiate studies to determine the bioeffects of millimeter waves.

We will continue research to develop criteria for design of crash/ escape protection systems. The Navy will begin full scale development of anthropometric dummies to mimic human response in complex acceleration environments, enhancing our design capability by a quantum leap. The flash blindness preventive goggles developed in the last few years are now becoming operational. A brief study last year of so-called "jet lag" and its effects on rapidly-deployed combat forces has already lead to some simple strategies for preventing this syndrome. Research on clothing and textiles is leading to new kinds of waterproof and protective fabrics, some of which offer promising leads for chemical protection.

o <u>Combat Casualty Care</u>. The third thrust area is concerned with treatment of casualties on the battlefield. Our program concentrates on improving our means of finding, protecting, caring for and transporting battle casualties. Our research emphasis is on care provided to the sick and injured before they arrive at definitive medical care facilities, and with care to be provided by non-physician units operating remote from definitive care. The Navy is continuing with development of computer-assisted diagnosis to provide the corpsman on remote duty, as a submarine patrol, with access to sophisticated medical advice. Other accomplishments for FY 1980 include development of an electromagnetic warming device for thawing frozen blood and blood products; alternatives to whole blood for battle casualty care; development of a new antishock drug, which will require further study. A new battlefield medical care doctrine is to be developed using the technical advances resulting from out casualty care research program.

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IV. CONCLUDING REMARKS

The total FY 1981 budget request for the S&T Program, including DARPA and DNA as well as the three Services, is $3.5 billion. This represents a real growth of six percent assuming an inflation rate of about eight percent.

We are applying these increased resources to build upon our successes and our strengths. Continued growth in S&T is essential to our future well-being and security. Already the Soviets are outspending us by 100 percent for RDT&E. Even with the advantages we have in our free society and our free commercial system, we cannot tolerate such a discrepancy indefinitely.

I am confident that the funding requested for FY 1981 will be adequate to ensure achievement of our objective of maintaining a level of technological supremacy which enables the United States to develop, acquire and maintain the military capabilities needed for our national security. We will be able to maintain a vigorous, healthy technology infrastructure which will enable us to continue a steady evolutionary growth in military technology, recognize and exploit revolutionary technical advances, and evaluate Soviet progress and advances in a rational and realistic fashion.

The growth in funding will be directed to essential programs and to enhance the cooperation among the government R&D community, the universities, and industrial laboratories. This combination of technical talent and genius is still without parallel anywhere else in the world, and when

supported by the technical talent of our Allies is more than a match for our adversaries. But without continued and steady support, the rate of progress of our military technology could become too low to sustain our present superiority.

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